

Lightweight anti-tank missile. In production and service.

Prime contractor: Messerschmitt-Bölkow-Blöhm GmbH

Powered by: Solid-propellant sustainer rocket motor. Non-jettisonable solid-propellant booster rocket

Airframe: Cylindrical fibre-paper body, with pointed conical nose. Large plastic cruciform wings, each with spoiler. Booster mounted under body

Guidance and Control: Wire guidance by line-of-sight command, via operator's joystick controller. Control by spoilers in wings

Warhead: Hollow charge, weighing 6lb (2.7kg) and able to penetrate more than 18.7in (475mm) of steel armour. Alternative anti-tank shrapnel (ATS) warhead

Length: 3ft 1.5in (0.95m)

Body diameter: 3.9in (0.100m)

Wing span: 1ft 7in (0.48m)

Copperhead

Anti-tank projectile. Under development.

Prime contractor: Martin Marietta Corporation

Airframe: Cylindrical body with cruciform flip-out narrow chord wings and tail-fins indexed in line

Guidance and Control: Laser-guided. Control via tail-fins

Warhead: High-explosive, weighing 14.1lb (6.4kg)

Length: 4ft 6in (1.37m)



Launch weight: 22.7lb (10.3kg)

Max speed: 190mph (306km/h)

Range limits: 1,310-6,560ft (400-2,000m)

Development and Service

This one-man anti-tank weapon system first entered service in 1960, and comprises the Cobra missile, a control box and cable links, with a junction box connected. Up to eight rounds can be fired selectively from a single control box. No launcher is required as the missile is designed for jump launching from the ground. The control box is completely self-contained and carries the firing button and control stick.

More than 170,000 Cobras have been delivered to the armies of Germany and many countries within and outside NATO. Manufacturing licences have been granted to Brazil, Italy, Pakistan and Turkey. The current version is known as the Cobra 2000 to indicate the extension of its maximum range to 2,000m.

USA

Launch weight: 140lb (63.5kg)

Range limits: 1.8-12.4 miles (3-20km)

Development and Service

Copperhead (XM712) is a Cannon-Launched Guided Projectile (CLGP). It has a laser seeker and is fired from existing 155mm howitzers, such as that fitted to NATO's self-propelled M-109A1, against all types of armoured and artillery targets marked by a laser designator. This gives Copperhead an advantage over ordinary 155mm artillery rounds in that it allows a high chance of a single shot kill, while the gun remains miles from the target. As an alternative, and in order to do away with the need for the ground observer/operator operating the laser designator in line-of-sight with the target, the designator can be carried in a helicopter (with all appropriate subsystems) or by a remotely-piloted vehicle.

Below: Copperhead strikes home.



First conceived in 1970, Copperhead subsequently made six direct hits against stationary and moving targets at various ranges, using a ground laser designator, during competitive trials. The full-scale development programme was initiated in July 1975 and in October of the same year a

Copperhead made a successful attack on a target while guided by a laser designator in an RPV. In February 1976, another successful attack was made by a Copperhead, this time fired at night and with the designator on board a Bell HueyCobra helicopter. The production decision was expected in 1979.

Crotale/Cactus

Close-range surface-to-air missile. In production and service.

Prime contractor: SA Engins Matra

Powered by: Single-stage SNPE Lens solid-propellant rocket motor

Airframe: Slim cylindrical body, with cruciform foreplanes mounted on ogival nose-cone and indexed in line with cruciform tail surfaces

Guidance and Control: Radio command guidance

Warhead: High-explosive, weighing 33lb (15kg) with infra-red proximity fuse

Length: 9ft 5.75in (2.89m)

Body diameter: 5.9in (0.15m)

Wing span: 1ft 9.25in (0.54m)

Launch weight: 187lb (85kg)

Max speed: Mach 2.3

Range limits: 1,640ft-5.3 miles (500m-8.5km)

Development and Service

Matra designed this highly-mobile all-weather missile to deal with aircraft flying at speeds up to Mach 1.2 at any height from 165ft (50m) to 9,850ft (3,000m) with a reaction time of only six seconds. Work on the missile started in 1964 and the prototype was completed in 1965, Matra being responsible for the missile and Thomson-CSF for

Right: Crotale missile in its launcher.

Below: Crotale launch vehicle armed with three missiles.

France

development of the system. Manufacture of the complete system started in late 1968, but no information was released publicly until May 1969, when the South African Defence Minister announced that French companies were developing for his country a weapon known as Cactus; it was later revealed that this weapon was known as Crotale in France. In 1969 successful launches were made at Landes, against target drones. Deliveries to South Africa began in late 1971, and the French Air Force uses Crotale systems for airfield defence. The missile system is thought to have also been ordered by Abu Dhabi, Egypt, Libya, Kuwait, Pakistan and Spain. Thomson-CSF has also adapted this weapon for a ship-based role (see Naval Crotale).



Four Crotale/Cactus missiles are carried in ready-to-fire condition on the standard Hotchkiss-Brandt all-terrain launch vehicle. This carries also a monopulse fire control radar which can track and transmit command signals simultaneously to two missiles. Acquisition after launch is facilitated by an infra-red device which locks on to the missile exhaust. An optical tracking device is also provided.

Cruise missiles

Air-launched cruise missiles. Possibly under development.

Development and Service

The UK, France and Germany are reported to be

An integrated TV tracking mode provides back-up guidance at low level. A second vehicle of the same type carries a pulse-Doppler surveillance and target acquisition radar with a range of 11.5 miles (18.5km), and can serve three launch vehicles. Twelve targets can be tracked simultaneously, and 12 missiles can be launched in pairs at six targets in 11 seconds.

UK/France/Germany

looking into the possibility of developing cruise missiles, in the case of the UK and France as possible replacements for submarine-launched ballistic missiles as their main strategic weapons for the mid-1980s.

Dragon (M47)

Medium anti-tank and assault missile. In production and service

Prime contractor: McDonnell Douglas Astronautics Company

Powered by: 30 pairs of small solid-propellant rocket motors, in rows around body



Airframe: Cylindrical body, of reduced diameter at nose and tail, with rounded nose. Three curved tail-fins which flip open after launch

Guidance and Control: Wire guidance, by automatic command-to-line-of-sight system. Control by side-thrusters around body

Warhead: High-energy anti-tank

Length: 2ft 5.3in (0.74m)

Fin span: 1ft 1in (0.33m)

Launch weight: 27lb (12.25kg)

Range limits: 164-3,280ft (50-1,000m)

Development and Service

Dragon was projected to replace the 90mm recoilless rifle, to which it is superior in range and accuracy. It was known initially as MAW (Medium Anti-tank/assault Weapon) and is able to carry a warhead large enough to destroy most armoured and other infantry targets, while being light enough to be carried and shoulder-fired by one man. In operation, the infantryman first mounts on the missile launch-tube a tracker, embodying the telescopic sight, a sensor device and electronics package. The glassfibre launch-tube forms a sealed container for the missile during transport and storage, and is enlarged at the aft end to accommodate a propellant container and breech. After acquiring the target in the sight, the operator launches the Dragon missile. As long as the sight remains on the target, the tracker will sense the position of the missile relative to the line of sight and transmit signals to maintain or correct the flight path. 'Steering' is achieved by causing the appropriate pairs of rocket motors, or side thrusters, to fire for both propulsion and guidance.

Left: Dragon.

USA

Entac (MGM-32A)

Anti-tank missile. In service.

Prime contractor: Nord-Aviation/Aérospatiale, Division Engins Tactiques

Powered by: Two-stage solid-propellant rocket motor

Airframe: Cylindrical body with rounded ogival nose. Rear-mounted cruciform wings, each with a spoiler

Guidance and Control: Wire-guided and roll-stabilised. Control by wing spoilers

Warhead: High-explosive, weighing 9lb (4.1kg) and able to penetrate more than 25.5in (650mm) of steel armour

Length: 2ft 8.5in (0.82m)

Body diameter: 6in (0.15m)

Wing span: 1ft 3in (0.38m)

Launch weight: 26.9lb (12.2kg)

Max speed: 190mph (305km/h)

Range limits: 1,300-6,600ft (400-2,000m)

Development and Service

One of the first wire-guided anti-tank missiles to



Development of the Dragon weapon system was started in 1964. Manned shoulder-fired tests began in mid-1968, and service testing in 1972. Dragon entered production in FY 1972. In September 1972, Raytheon Company won a contract as an alternate source for the Dragon. First deliveries by Raytheon were made to the US Army at the beginning of 1974, and deliveries continue. The US Army, Marine Corps, National Guard and forces of several other countries are now equipped with Dragon. A night tracker and a viscous damped mount are also under development for use with the missile.

Left: Dragon launcher.

France

enter large-scale production, Entac (ENgin Téléguidé Anti-Char) was adopted in its Model 58 form by the French Army in 1957. Over 139,417 have been delivered to the armies of 13 countries, including Australia, Belgium, Canada, Indonesia and the USA. Entac is known as the MGM-32A by the US Army. Production has now ended.

Entac is intended primarily for use by infantry and was developed by the Direction Technique des Armements Terrestres (DTAT). An operator can control and fire up to 10 missiles from a single firing post, with a maximum operator-to-missile distance of 360ft (110m). Alternatively, four Entacs can be mounted in pairs on each side of a jeep, inside their box-like container-launchers. The operator uses an optical sight to locate and track the target and a manual control to command the missile on to his line-of-sight.

Below left: Entac missile mounted on a jeep.

Below: Ground-launched Entac.



Exocet (MM38, AM39 and MM40)

Ship-launched and air-launched anti-ship tactical missile. In production and service.

Data: AM39

Prime contractor: Aérospatiale, Division Engins Tactiques

Powered by: Tandem two-stage solid-propellant motor; burn time 2sec and 150sec respectively

Airframe: Cylindrical body, with pointed ogival nose. Cruciform sweptback wings, indexed in line with cruciform tail control surfaces

Guidance and Control: Inertial guidance system, associated with TRT AHV-7 FM radio-altimeter, and with active terminal homing radar. Control by tail surfaces

Warhead: High-explosive, weighing 352lb (160kg)

Length: 15ft 4.25in (4.68m)

Body diameter: 1ft 1.75in (0.348m)

Wing span: 3ft 3.5in (1.00m)

Launch weight: 1,433lb (650kg)

Cruising speed: Mach 0.93

Range: 32.25-43 miles (52-70km)

Development and Service

Following the sinking of the Israeli destroyer *Eilat* by 'Styx' ship-to-ship missiles, it became a matter of high priority to evolve a defence against such attack. Once missiles like 'Styx' have been launched they are difficult to intercept. In consequence, Nord-Aviation (now Aérospatiale) concentrated on producing a weapon that would sink enemy missile-armed boats before they were near enough to launch their own attack. Exocet is the answer to that requirement and is one of the most formidable naval weapons ever

conceived, being able to travel to the target only 6.5-10ft (2-3m) above the water, in all weathers, at just below the speed of sound. An oncoming Exocet would thus be extremely difficult to detect by ship-board radar, and it is designed to be impervious to enemy electronic countermeasures (ECM).

The basic MM38 Exocet weapon system can be fitted to any class of surface warship, including fast patrol boats, provided the ship is fitted with surveillance and target indicating radar, a vertical reference plane gyro and a log to indicate its speed through the water, plus a fire control system. The range and bearing of the target are fed into the missile's guidance system before launch; its cruising height is maintained at very low level by a radio-altimeter linked to its controls.

Evaluation by the French Navy began in October 1972, with the Royal Navy and West German Navy participating. Production for these countries started in January 1973. The 100th MM38 was launched in October 1978. Development of Exocet for an air-to-surface role followed. Air-launch tests began in April 1973 from a Super Frelon helicopter. The missile used was a modified MM38 called AM38, which incorporated a one-second ignition delay to permit the weapon to fall clear of the launch aircraft before firing. A similar delay is incorporated into the AM39 air-to-surface Exocet that was first fired from a Super Frelon in December 1976 and from a Super Etendard in 1977. Production began in 1977 for the French Navy and for export. The AM39 is shorter and lighter than the MM38 and has a new motor which gives it a range of 32.25miles (52km) when launched from a helicopter at 69mph (110km/h) at a height of 330ft (100m), or 37-43 miles (60-70km) when launched from a Super Etendard at 330-33,000ft (100-10,000m). As well as being carried by the French Navy's Super Etendard aircraft, it will also arm the Mirage F1, and can be installed on some helicopters.

France

More than 1,100 MM38/AM39s have been ordered by the three navies mentioned above and those of Argentina, Belgium, Brazil, Chile, Ecuador, Greece, Indonesia, Iraq (AM39), Kuwait, Malaysia, Morocco, Nigeria, Pakistan (AM39), Peru, Portugal and Thailand.

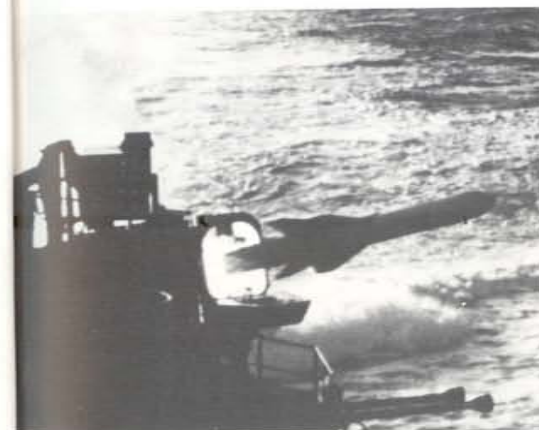
Proposed new versions of Exocet include the MM39, MM40 and SM39. However, only the longer range MM40 (which can be ship or coastal defence land vehicle mounted in four-round launchers) is being developed at a serious pace — the MM39 having been abandoned and the SM39 submarine-launched version receiving only limited interest.

Below: Exocet MM38 ship-launched missile.

Right: Six Exocet MM38 launchers forward of superstructure on the French Navy's *Jeanne d'Arc*.

Bottom: Exocet MM40 coastal defence vehicle.

Below: Exocet test round on a Super Frelon helicopter.



Falcon (AIM-4D)

Air-to-air missile. In service.

Prime contractor: Hughes Aircraft Company
Powered by: Thiokol M58-E4 solid-propellant rocket motor of 6,000lb (2,720kg) st

Airframe: Cylindrical body with tapered and rounded glass-tipped nose. Cruciform vanes aft of nose, indexed in line with long-chord cruciform delta wings. Cruciform tail control surfaces aft of wing trailing-edges

Guidance and Control: Infra-red homing guidance. Control by tail surfaces

Warhead: High-explosive

Length: 6ft 7.5in (2.02m)

Body diameter: 6.4in (0.163m)

Wing span: 1ft 8in (0.51m)

Launch weight: 134lb (61kg)

Max speed: Mach 4

Max range: 6 miles (9km)

Development and Service

Hughes began work on the original GAR-1 semi-active radar homing version of Falcon in 1947. The first of about 4,000 production models appeared in 1954, followed by more than 12,000 improved GAR-1Ds (later redesignated AIM-4As). Simultaneously, the company delivered about 16,000 GAR-2s and 9,500 GAR-2As, with pursuit-course infra-red homing. Later redesignated AIM-4C, these offered the advantage that the launch aircraft was free to break off the engagement once the self-homing missiles had been launched. The final production version of this basic Falcon family was the AIM-4D, combining the basic airframe of the 'C' with the improved infra-red homing head of the AIM-4G Super Falcon. Many thousands of older Falcons were converted into 'Ds', which continue to arm F-101 interceptors of the Canadian Armed Forces (the only aircraft now armed with early version Falcons). Under a 1969 USAF contract, Hughes evolved the AIM-4H with a new warhead incorporating an active optical target detection



Above: AIM-4D Falcons.

device (AOTDD). A solid-state laser device in the AOTDD detonated the warhead without requiring a direct hit, making the 'H' better suited to close air combat. However, US budget economies precluded further development and production. (See also HM-58 and Super Falcon.)

USA

Falcon (HM-55/HM-58) (Swedish Air Force designations RB27 and RB28)



Air-to-air missiles. In production and service.

Prime contractors: Hughes Aircraft Company/Saab-Scania Aktiebolag

Powered by: Single-stage solid-propellant motor
Guidance and Control: HM-55 has Hughes semi-active radar homing guidance; HM-58 uses infra-red homing system

Warhead: High-explosive, RB27 with proximity fuse

Length: RB27 7ft 1in (2.16m)

RB28 6ft 7.5in (2.02m)

Max body diameter: RB27 11in (0.28m)

RB28 6.4in (0.163m)

Wing span: RB27 2ft 0in (0.61m)

RB28 1ft 8in (0.51m)

Bottom left: Two RB27 (HM-55) missiles under the fuselage of a J35F Draken.

Launch weight: RB27 262lb (119kg)

RB28 134lb (61kg)

Max speed: RB27 Mach 3

RB28 Mach 4

Max range: RB27 6.2miles (10km)

RB28 5.6 miles (9km)

Development and Service

The HM-55 and HM-58 export versions of the Falcon are built under licence in Sweden by Saab-Scania, under the Swedish Air Force designations RB27 and RB28 respectively. In general appearance the HM-55 resembles the AIM-26B Falcon (qv). Its all-weather guidance system makes possible attack from any direction, including head-on, and its launch speed makes it compatible with Mach 2 aircraft. The Swedish Air Force deploys it on J35F Draken interceptors in combination with the HM-58. This is an infra-red homing weapon generally similar to the AIM-4D Falcon. The Swiss Air Force has also adopted the HM-55 as standard armament for its Mirage IIIS fighters.

Firestreak

Air-to-air missile. In service.

Prime contractor: British Aerospace Dynamics Group

Powered by: Solid-propellant rocket motor

Airframe: Cylindrical metal body, with cruciform wings mounted more than half-way back from nose and indexed in line with cruciform tail control surfaces. Pointed eight-sided glass nose, with two narrow rings of small windows over infra-red optics on fore-part of body

Guidance and Control: Infra-red homing guidance. Control by tail-fins

Warhead: High-explosive, weighing 50lb (22.7kg), with infra-red proximity fuse

Length: 10ft 5.5in (3.19m)

Body diameter: 8.75in (0.225m)

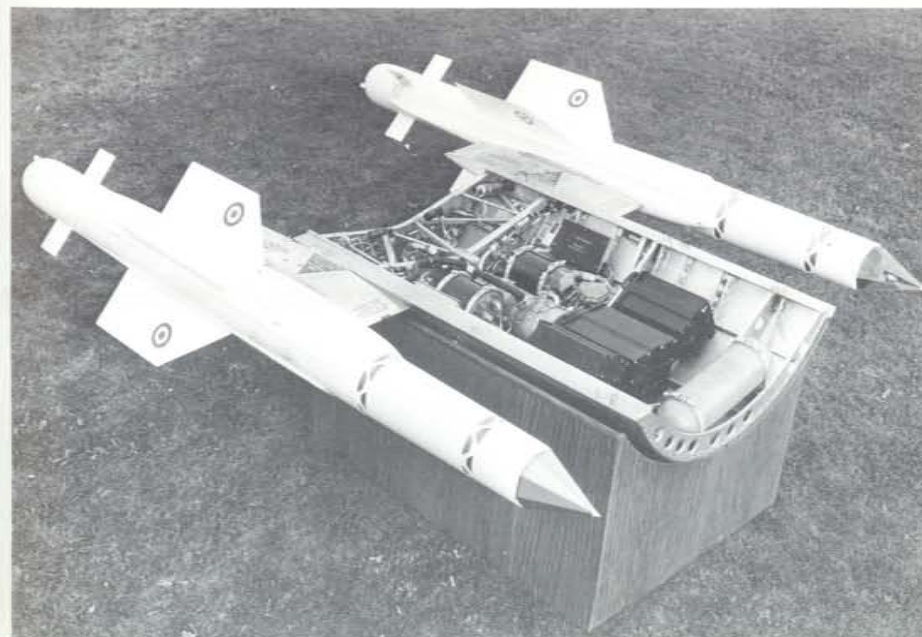
Wing span: 2ft 5.5in (0.75m)

Launch weight: 300lb (136kg)

Cruising speed: above Mach 2

Range limits: 0.75-5 miles (1.2-8km)

Below: Firestreak missile pack for a Lightning interceptor.



UK

USA

Development and Service

Firestreak was developed for use against high-speed and manoeuvring aircraft and is said to have achieved a success rate of more than 85% in trials by the RAF and Royal Navy at all altitudes and in all weather conditions. Control is by a proportional navigation system. The guidance system uses a gyro-mounted telescope which focuses infra-red radiation on to a detector cell. The angular difference between the

axis of the homing head and the sight-line between the missile and target aircraft is then computed and corrections are made to reduce the angle and align the missile on target. Firestreak's only limitation is that it must be fired from astern the target — a shortcoming that does not apply to the further-developed Red Top (qv). It is standard armament on RAF Lightning interceptors.

FRAS-1

Anti-submarine rocket. In service

Warhead: Nuclear depth charge or torpedo

Range: approx 15.5 miles (25km)

Frog-3, 4 and 5

Unguided surface-to-surface bombardment missiles. In service.

Data: 'Frog-4'

Powered by: Two-stage solid-propellant motors.

12 small nozzles around main nozzle of booster

Airframe: Tandem two-stage all-metal casings, of cylindrical shape. Conical nose-cone. Fixed cruciform tail-fins

Guidance and Control: No guidance system. Spin stabilised

Warhead: Alternative nuclear or high-explosive

Length: 33ft 6in (10.20m)

Body diameter: about 1ft 3.7in (0.40m)

Fin span: 3ft 6in (1.05m)

Launch weight: 4,400lb (2,000kg)

Max range: 30 miles (50km)

Development and Service

Like the earlier 'Frog-1 and 2', which are no longer in service, these missiles are all unguided artillery rockets; but have two stages in tandem and are

USSR

Development and Service

This unguided anti-submarine weapon is similar in concept to the US Asroc.

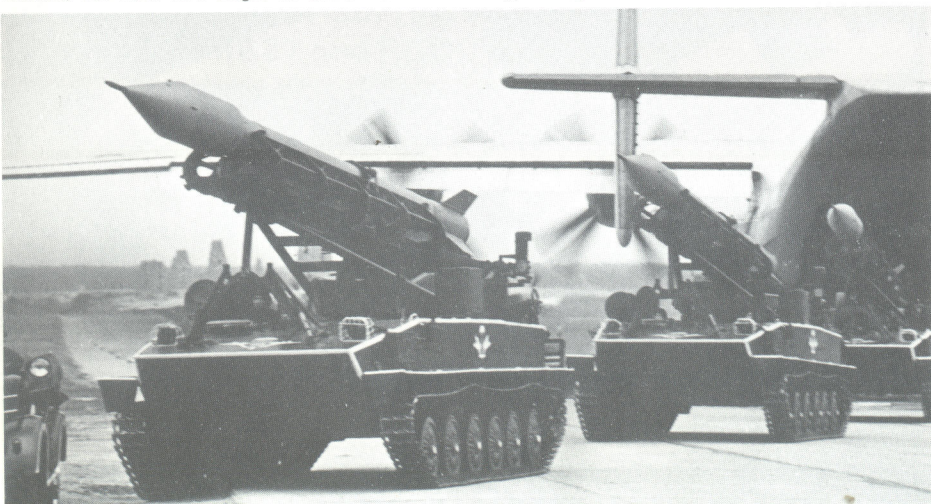
USSR

carried on an uncovered launch rail by a tracked vehicle based on the PT-76 amphibious reconnaissance tank. (Frog is a NATO reporting name standing for Free Rocket Over Ground.) The 'Frog-2', of which eight were paraded through Moscow in November 1957, was followed successively by 'Frog-3', with a more cylindrical bulbous warhead, now considered obsolete; the 'Frog-4', differing only in having a warhead of the same diameter as the second-stage casing; and 'Frog-5' with yet another variation in warhead. The latter is also believed to be shorter than 'Frog-4', of greater body diameter, to be heavier and with increased range. These rockets were all delivered in large numbers to the Soviet Army and its Warsaw Pact allies. 'Frog-4' also serves in Cuba, and 'Frog-5' possibly in North Korea.

Below: 'Frog-5s' being unloaded from an Antonov An-22 transport aircraft.

Top right: 'Frog-3'.

Right: 'Frog-7'.



Frog-7

Unguided surface-to-surface bombardment missile. In service.

Powered by: Solid-propellant motor. Eighteen small nozzles around main nozzle

Airframe: Cylindrical casing, with cruciform cropped-delta tail fins. Pointed nose-cone

Guidance and Control: No guidance system. Spin stabilised

Warhead: Alternative nuclear or high-explosive.

Length: approx 29ft 6in (9m)

Body diameter: 1ft 11.6in (0.60m)

Range: approx 37 miles (60km)

Development and Service

'Frog-7' was first seen in Moscow on 7 November 1965. It reverts to the original single-stage

Gabriel

Ship-launched surface-to-surface missile. In production and service.

Data: Gabriel Mk1

Prime contractor: Israel Aircraft Industries Ltd

Powered by: Solid-propellant rocket motor

Airframe: Basically cylindrical body, tapering towards the tail. Rectangular cruciform wings and tail surfaces, indexed in line with each other. Ogival nose-cone

Guidance and Control: Inertial guidance system, with radio altimeter, or manual/optical system, with I-band semi-active radar terminal homing. Control by rear fins

Warhead: High-explosive, weighing 396lb (180kg)

Length: 11ft 0in (3.35m)

Body diameter: 12.8in (0.325m)

Wing span: 4ft 6.5in (1.39m)

Launch weight: 882lb (400kg)

USSR

configuration. Also, like most of the other battlefield missiles identified since the mid-1960s, it is transported on a wheeled vehicle (Zil 135) rather than the former tracked launcher. Its range can be shortened by use of speed brakes.

'Frog-7s' were deployed rapidly in the Soviet Army and with the armed forces of Russia's friends and allies, including Warsaw Pact nations, Egypt, Iraq, North Korea and Syria. Some photographs have shown the transporter/launcher carrying two additional missiles, to each side of the ready-to-fire 'Frog-7' on the launch-rail.

Israel

Max speed: Mach 0.7

Range limits: 1.24-13.7 miles (2-22km)

Development and Service

This subsonic ship-to-ship weapon is one of only two missiles of Israeli design of which details have yet been released officially. Gabriel was developed by IAI in collaboration with the Israeli Navy, the obvious purpose being to provide a counter to missile-launching ships like the Egyptian Osa class which sank the Israeli destroyer *Eilat* in 1967. It has been operational since early 1970 on Israel's 12 French-built Saar class gunboats, six of which carry eight launchers each — two three-round swivelling launchers amidships and two single fixed launchers forward — and six with only two three-round launchers each. Fifteen Reshef class fast attack boats, built in Israel, each carry seven Gabriel launchers aft of the superstructure.

Gabriel is delivered inside a glassfibre container which embodies the launching rail and is simply installed on the ship-board mountings without further test or adjustment. It can be launched in bad weather or rough seas, and is said to approach its target only a few metres above the water, lessening the possibility of detection. IAI describe it as an automatic homing weapon and claim that it is impervious to enemy electronic countermeasures. A long-range version of Gabriel was announced in 1972, incorporating modifications in the propulsion

and guidance (including a home-on-jam mode) systems. Range is more than 25 miles (41km). This version is also in production and service and both versions have been exported.

A successor to the Gabriel Mk 2 is reported to be under development. It will be a supersonic sea-skimming missile with a longer range than earlier Gabriels and with improved guidance. Surface and air launches may be possible. It could enter service in 1984.

Gainful (SA-6)

Surface-to-air missile. In service.

Powered by: Integral rocket-ramjet, employing solid propellant for both phases of operation

Airframe: Cylindrical body, with cruciform wings at mid-body, indexed in line with cruciform tail surfaces. Slim cylindrical duct from forward of wing almost to tail on each side of body. Shorter ducts of similar form above and below body. Ducts are air intakes for ramjet phase of flight

Guidance and Control: Radio command; semi-active radar terminal homing

Warhead: High-explosive, weighing 176lb (80kg)

Length: 20ft 4in (6.2m)

Body diameter: 1ft 1.25in (0.335m)

Launch weight: 1,212lb (550kg)

Cruising speed: Mach 2.8

Ceiling: 11 miles (18km)

Slant range: 18.5-37 miles (30-60km)

USSR

Development and Service

First displayed in public during a Moscow parade on 7 November 1967, this compact anti-aircraft missile has since become a standard weapon in the Soviet forces and is deployed in Bulgaria, Czechoslovakia, Egypt, Hungary, Iraq, Libya, Mozambique, Poland, Syria and Vietnam. It is somewhat larger than the American Hawk and fulfils a similar role, by providing a rapid-reaction defence against aircraft flying at low and medium altitudes. Three 'Gainful' missiles are carried side-by-side atop a modified PT-76 tracked transporter/launcher.

Missiles of this type were used very effectively by the Arab forces during the October 1973 war with Israel. Captured SA-6s proved to have an integral rocket-ramjet propulsion system of the kind described under the ASALM entry, but using solid propellant in both the rocket and ramjet phases of flight. In the ramjet cruise phase, the exhaust from a solid-propellant gas generator is mixed with air in the combustion chamber and further ignition takes place, greatly increasing mass flow.



Galosh (ABM-1B)

Anti-ballistic missile. In service.

Powered by: Rocket motors with four first-stage nozzles

Guidance and Control: Radar command

Warhead: Nuclear of several megaton yield

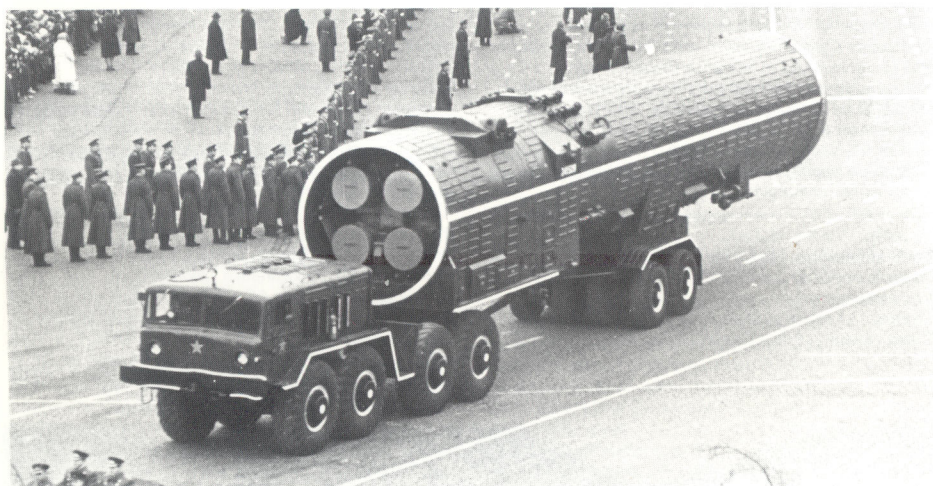
Range: over 200 miles (320km)

Development and Service

'Galosh' has been under development at least as long as its US counterparts of the Safeguard ABM system. The ribbed cylindrical container in which it is transported (and from which it is, presumably, fired) was first displayed on a tractor/trailer in a Moscow parade on 7 November 1964. On that occasion the Soviet commentator referred to 'Galosh' as an anti-ballistic-missile (ABM) weapon. 'Galosh' is the

missile installed in 64 ABM launchers at four sites around Moscow, each with 'Try Add' engagement radars. The early warning radar, known to NATO as 'Hen House', is described as being 'the size of three football fields lined up end-to-end and standing on their sides'. Target acquisition and tracking is by phased-array 'Dog House/Cat House' radars. The radars are being improved.

Very little is known of the 'Galosh' missile itself, except that four first-stage nozzles have been visible inside the container, which is 67ft (20.4m) long with a diameter of 9ft (2.75m). Current ABM development in the Soviet Union is reportedly concentrating on a rapidly deployable system, incorporating improved radars and a new high-altitude missile as good as the projected US Improved Spartan missile, with 'loiter' capability.



Gammon (SA-5)

USSR



USSR

Long-range surface-to-air missile. In service.

Powered by: Multi-stage rocket motors. Solid-propellant first-stage booster

Airframe: Cylindrical booster, with large cruciform cropped-delta fins. Smaller-diameter second stage is also cylindrical, with ogival nose; it carries large cropped-delta cruciform wings, each with a control surface inset in its trailing-edge. Cruciform tail control surfaces, on tapering tail of second stage, are indexed in line with wings and at 45 degrees to booster fins. Warhead may separate as third stage and use an in-built rocket motor during final approach to target

Guidance and Control: Radar homing system.

Control by wing trailing-edge surfaces and second-stage tail-fins

Warhead: Probably interchangeable nuclear and high-explosive types

Length: 54ft 0in (16.50m) with nose-probe

Body diameter: Booster 3ft 3.5in (1.00m)
2nd stage 2ft 7.5in (0.80m)

Wing span: 13ft 0in (3.96m)

Launch weight: approx 22,050lb (10,000kg)

Max speed: over Mach 3.5

Range: approx 155 miles (250km)

Effective ceiling: 18 miles (29km)

Development and Service

Largest Russian surface-to-air missile yet revealed publicly, 'Gammon' (known originally as 'Griffon') has been trundled through Moscow on a trailer regularly since November 1963. It was then described by the Soviet commentator as an anti-missile missile, but does not appear to have the capability of intercepting an ICBM warhead. Its use is almost certainly limited to an anti-aircraft role, with limited effectiveness against tactical ballistic missiles and air-to-surface weapons.

Ganef (SA-4)

Surface-to-air missile. In service.

Powered by: Ramjet sustainer. Four solid-propellant wrap-round boosters, with canted nozzles, which jettison after burn-out

Airframe: Cylindrical main body, with smaller-diameter centre-body carrying pointed conical warhead. Cruciform pivoted wings on fore-part of main body, indexed at 45 degrees to fixed cruciform tail-fins. Boosters equi-spaced around body aft of wings

Guidance and Control: Command guidance system, with possible semi-active radar terminal homing. Control via pivoted wings

Warhead: High-explosive

Length: 30ft 0in (9.15m)

Max body diameter: 2ft 8in (0.80m)

Wing span: 7ft 6in (2.30m)

Launch weight: approx 2,200lb (1,000kg)

Ceiling: 80,000ft (24,400m)

Max speed: Mach 2.5

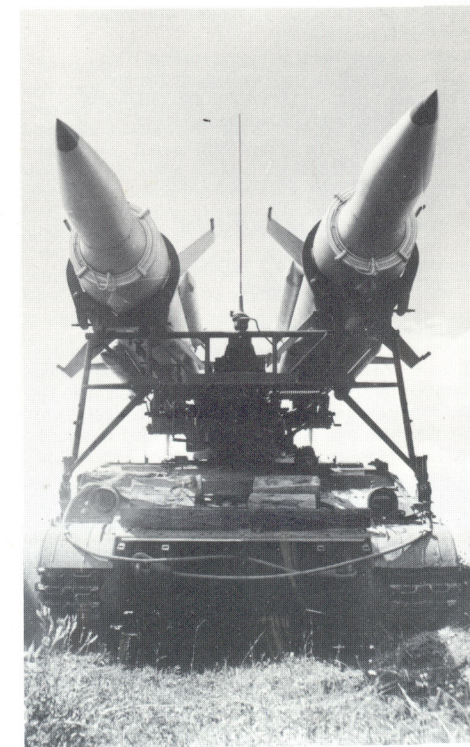
Range: approx 43.5 miles (70km)

Development and Service

This weapon was probably evolved to provide Soviet land forces with a highly mobile anti-aircraft defence effective up to the service ceiling of most contemporary combat aircraft. It is said to operate in forward areas, about 6 miles (10km) behind the army front line, which can be supported by the use of an armoured launch vehicle. The annular air-intake between the main body and the centre-body suggests the use of a ramjet sustainer engine, which would be consistent with long range. The twin-round tracked launcher carrying 'Ganef' was first shown in a Moscow parade in May 1964. Since then this missile system has been deployed widely in the Soviet Union and serves also in Czechoslovakia and East Germany. 'Ganefs' were also despatched to

USSR

Egypt, but these are no longer operational. 'Ganef' can be transported on its launch vehicle by aircraft like the An-22 freighter. It may have a surface-to-surface capability.



Gaskin (SA-9)

This is a mobile surface-to-air weapon system using a tube-launched missile similar to the SA-7 ('Grail') but larger, with a heavier warhead and longer range. Two two-round launchers are mounted on a BRDM-2 armoured amphibious vehicle. It is thought that a new version of 'Gaskin' is currently under development. 'Gaskin' is in service with Warsaw Pact nations, Egypt and, perhaps, Syria.



GBU-8 (HOBOS) and GBU-15

Homing bomb system. In production and service (GBU-8).

Data: Initial versions of HOBOS

Prime contractor: Missile Systems Division, Rockwell International

Airframe: Cylindrical nose and tail assemblies, linked by four long-chord, short span strakes, fit over standard bomb casing. Cruciform tail-fins integral with rear end of strakes, each fitted with trailing-edge flap control surface

Guidance and Control: Electro-optical (TV) guidance system. Control by flaps on tail-fins

Warhead: Standard Mk 84 2,000lb (907kg) or M118E1 3,000lb (1,360kg) bomb

Length: Mk 84 12ft 5in (3.78m)
M118E1 12ft 2in (3.71m)

Body diameter: Mk 84 1ft 6in (0.46m)
M118E1 2ft 0in (0.61m)

Wing span: Mk 84 3ft 8in (1.12m)
M118E1 4ft 4in (1.32m)

Launch weight: Mk 84 2,240lb (1,016kg)
M118E1 3,404lb (1,544kg)

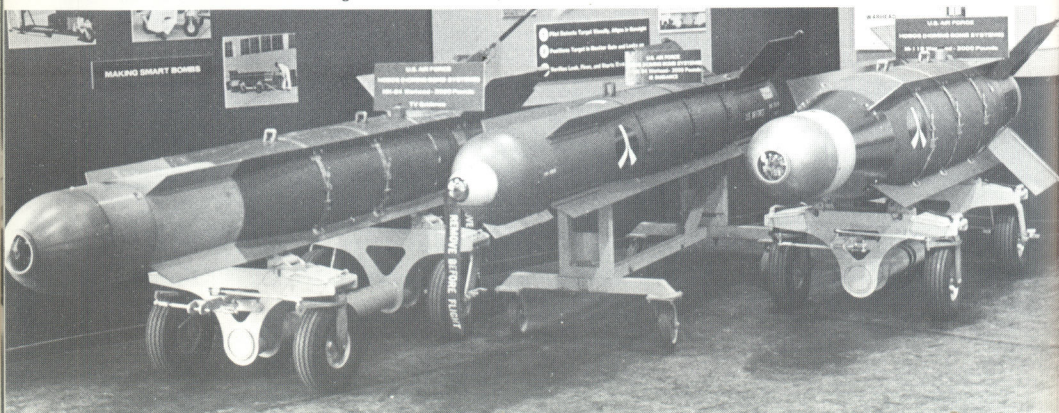
Development and Service

Developed under the USAF's electro-optical guided bomb (EOGB) programme, HOBOS (Homing Bomb System) comprises a kit of parts which can be mounted on standard Mk 84 and M118E1 bombs to convert them into highly-accurate guided weapons. Each kit consists of a forward guidance assembly,

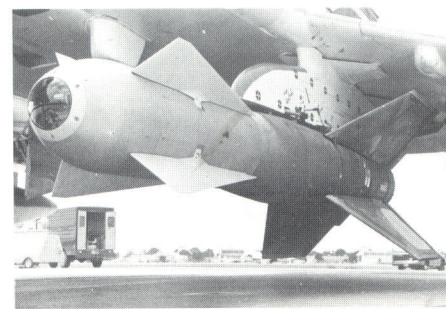
the interconnect section (including the bomb) and an aft control section (including an autopilot). Most current production HOBOS missiles are built around Mk 84 bombs and use the TV type of guidance that was developed on the Army Hornet experimental air-to-surface missile. With this, the operator has only to lock the missile's stabilised vidicon camera on to the target before launch, by means of a TV monitor. The missile then homes automatically on the target after launch. The normal bomb suspension and release systems are unchanged.

Use of HOBOS in Vietnam, notably against aircraft in revetments, jungle roads and bridges, led to further production for the US services and for foreign customers, including Greece and Israel. Development has also continued, and the USAF designation for the weapon system in its latest form is GBU-15, covering a family of modular glide weapons. To provide day and night all-weather capability, the original TV guidance system can be replaced by imaging infrared or laser seekers, and a midcourse system that includes distance measuring equipment (DME) for improved accuracy. Alternative warheads can include the GBU-75 cluster munition dispenser. The resulting glide bombs have self-contained guidance

Below: TV-guided HOBOS and infra-red guided HOBOS using Mk 84 bombs (left and centre), and TV-guided HOBOS using M118E1 bomb.



USSR



Above: GBU-15 Cruciform Wing Weapon.

Above right: GBU-15 Planar Wing Weapon.

and are extremely accurate with long-range stand-off capability. Direct and indirect attack versions are produced by using different interchangeable modular elements. For indirect attack a data link module is used to allow control during flight. The two basic versions of the system are the Planar Wing Weapon (PWW) and the Cruciform Wing Weapon (CWW).

Gecko (SA-8)

Surface-to-air weapon system. In service.

Powered by: Solid-propellant dual-thrust rocket motor.

Airframe: Cylindrical body with canard control surfaces and fixed tail-fins.

Guidance and Control: Command guidance with infra-red terminal homing. Control by canard surfaces.

Warhead: High-explosive, about 90-110lb (40-50kg) weight with proximity fuse

Length: 10ft 6in (3.2m)

Body diameter: 8.25in (0.21m)

Tail span: 2ft 1in (0.64m)

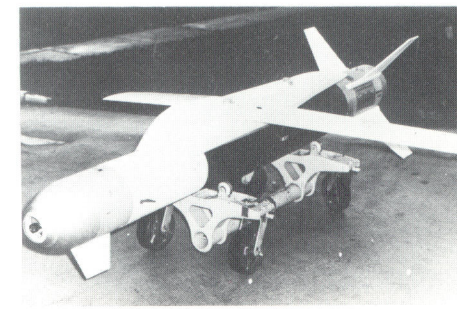
Max speed: approx Mach 1.5

Ceiling: approx 19,700ft (6,000m)

Range: 5-7.5 miles (8-12km)

Development and Service

Soviet counterpart to Roland, this missile system was first displayed publicly in a Moscow parade on



The former uses TV data or DME guidance and has a wing span of 11ft 4in (3.45m); Hughes Aircraft Company is responsible for system integration. During the initial launch of a PWW weapon, on 15 November 1977 (by a Boeing B-52 over the White Sands Missile Range, New Mexico), a 'lethal' hit was made on a simulated power-plant target. The indirect attack version of the CWW began flight tests in February 1975, and more than 50 had been launched by July 1978. This version is expected to be the first in US service.

USSR

7 November 1975. Fire-control equipment and quadruple launcher for the short-range all-weather missiles are mounted on a rotating turret, carried by a new three-axle six-wheel vehicle that appears to be amphibious. Surveillance radar, with an estimated range of 18 miles (29km), folds down behind the launcher, enabling the weapon system to be airlifted by Soviet transport aircraft. Tracking radar is of the pulsed type, with an estimated range of 12-15 miles (19-24km). Two 'Gecko' missiles can be launched simultaneously at the same or separate targets. The SA-8 was thought to be at a service evaluation stage in early 1976, and is now in service with the Soviet forces. The same missile is thought to be used in the naval SA-N-4 system.

Below: 'Gecko' launch vehicles in Moscow parade, November 1977.



Genie (AIR-2A)

Unguided air-to-air nuclear missile. In service.

Prime contractor: McDonnell Douglas Astronautics Company

Powered by: Thiokol SR49-TC-1 solid-propellant rocket motor of 36,000lb (16,330kg) st

Airframe: Cylindrical body with cruciform tail-fins, each with movable tip, and an ogival nose of greater basic diameter than body

Guidance and Control: No guidance system

Warhead: Nuclear, with yield reported as 1.5 kilotons

Length: 9ft 7in (2.91m)

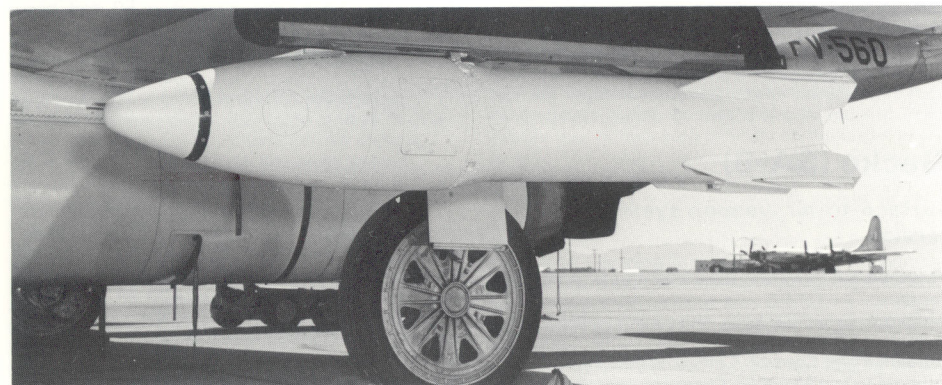
Body diameter: 1ft 5.35in (0.44m)

Fin span: 3ft 3.5in (1.00m)

Launch weight: 820lb (372kg)

Max speed: Mach 3

Max range: 6 miles (9.6km)



Goa (SA-3/SA-N-1)

Surface-to-air close-range missile. In service.

Powered by: Two-stage solid-propellant rocket motors

Airframe: Two basically cylindrical stages, in tandem. Booster fitted with large rectangular cruciform fins. Second stage has cruciform fixed wings at rear and cruciform cropped-delta control surfaces on the tapered nose-cone

Guidance and Control: Radio command with radar terminal homing. Control by movable foreplanes

Warhead: High-explosive

Length: 22ft (6.7m)

Body diameter: Booster 2ft 0in (0.60m)

Second stage 1ft 6in (0.45m)

Wing span: 4ft 0in (1.22m)

Development and Service

Although Genie is an unguided rocket, it justifies inclusion in this book by reason of its nuclear warhead. It was the first nuclear-tipped air-to-air missile ever tested in a live firing when, on 19 July 1957, it was launched from a Northrop F-89J Scorpion at Indian Springs, Nevada. Immediately after launch, at a height of 15,000ft, the pilot of the fighter turned sharply to escape the blast and the missile was detonated from the ground after travelling three miles (4.8km). USAF observers who stood directly under the point of detonation for an hour suffered no ill effects.

Several thousand Genies were delivered, many of which continue in first line service with F-106 squadrons of the USAF and CF-101F squadrons of the Canadian Armed Forces, the only nuclear weapons now in Canadian service. They are designed to be fired automatically and detonated by the Hughes fire-control system fitted in each aircraft. A training version, without nuclear warhead, is also in service.

Ceiling: 40,000ft (12,200m)
Max speed: Mach 2
Range: over 18.5 miles (30km)

Development and Service

Russia's 1961 counterpart to the American Hawk, 'Goa' is the anti-aircraft missile which caused much concern to the Israeli Air Force when 14 batteries supplemented earlier 'Guidelines' near the Suez Canal ten years later. It is effective over a slant range of more than 18.5 miles (30km) to a height of over 40,000ft (12,200m), and is known in America as the SA-3 or SAM-3 in its land-based version. Its compact form is evident from the fact that pairs of 'Goas' can be transported on the Zil 157 truck that is used as a tractor for the 'Guideline' and 'Guild' trailer-transporters and has been carried on a tracked

USA



vehicle. 'Goas' are in service with Warsaw Pact countries, Egypt, India, Iraq, Libya, Peru, Syria, Vietnam, Uganda and Yugoslavia.

In its ship-based form (SA-N-1) 'Goa' is standard armament in the Soviet Navy, on a twin-round launcher very like that used for the American Tartar missile. Four cruisers of the Kresta I class and 19 destroyers of the Kashin class each carry two launchers, fore and aft. Four cruisers of the Kynda class have a single twin-launcher on their fore-deck; eight destroyers of the Kanin class and eight of the

Goblet (SA-N-3)

Surface-to-air missile. In service.

Slant range: approx 37 miles (60km)

Development and Service

Little is known about this missile. It arms the helicopter carriers *Leningrad* and *Moskva*, the

Grail (SA-7)

Shoulder-fired surface-to-air missile. In service.

Guidance and Control: Initial optical aiming, with infra-red terminal homing. Control by foreplanes

Warhead: High-explosive, weighing 5.5lb (2.5kg)

Length: 4ft 5in (1.35m)

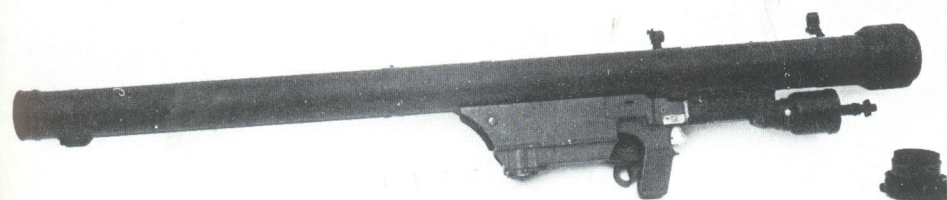
Body diameter: approx 2.75in (7cm)

Launch weight: approx 21lb (9.5kg)

Max speed: Mach 1.5

Range: 11,500ft (3,500m)

Operating height limits: 165-5,000ft (50-1,500m)



Kotlin class have a similar launcher on their after deck.

A photograph of a twin-launcher on a destroyer, issued by *Tass* in 1971, showed missiles of the 'Goa' type with an additional set of small tail-fins between the booster and second-stage wings. The wings also appear to carry trailing-edge control surfaces.

Above left: 'Goa'.

Above: Soviet Kashin class destroyer with 'Goa' missiles fore and aft.

USSR

aircraft carriers *Kiev* and *Minsk*, five Kara and 11 Kresta-II missile cruisers. The fire control radar system is known by the NATO designation 'Head Light'. It has been suggested that 'Goblet' is related to the land-based 'Gainful'.

USSR

Development and Service

In the later stages of the Vietnam war the North Vietnamese started using a man-portable, shoulder-fired, anti-aircraft missile that was manufactured in Russia. The same missile system was used widely by Arab forces during the October 1973 war with Israel, and captured examples proved to be similar in principle to the US Redeye. 'Grail' is a tail pursuit weapon, which has proved successful against low-flying helicopters and subsonic fixed-wing aircraft. An improved Mk 2 version has also been built in which the launch tube and equipment differs considerably from that of the earlier 'Grail', and is

said to incorporate an IFF system. Operational altitude could be tripled. SA-7s are in service with Warsaw Pact countries, Angola, Cuba, Egypt, Ethiopia, Iraq, Libya, Kuwait, North Korea, Mozambique, Peru, Syria, Vietnam, South Yemen and Yugoslavia. A naval version of 'Grail' (SA-N-7)

has also entered service and arms Osa class missile boats, Shershen class fast attack torpedo boats and other boats including 60 Polnochniy class landing craft, of the Soviet Navy, and a few Egyptian boats. (See also 'Gaskin'.)

GSRS

Surface-to-surface unguided rocket. Under development

Warhead: M42 anti-tank submunitions, AT-2 mine or terminal homing mine, or smoke

Range: 18.6 miles (30km)

Development and Service

The General Support Rocket System has been conceived as a weapon for deployment in Europe where Warsaw Pact nations have a far greater artillery force than NATO countries. The GSRS is designed to overcome this lack of firepower and will be centred around a 13ft (4m) long and 9in (0.227m) diameter unguided rocket with interchangeable warhead. Two six-round pallets will be carried inside a hydraulically-jacked launch container onboard the XM-723 Infantry Fighting Vehicle. Main targets for the GSRS will be armoured vehicle concentrations, anti-aircraft missile sites and artillery forces.

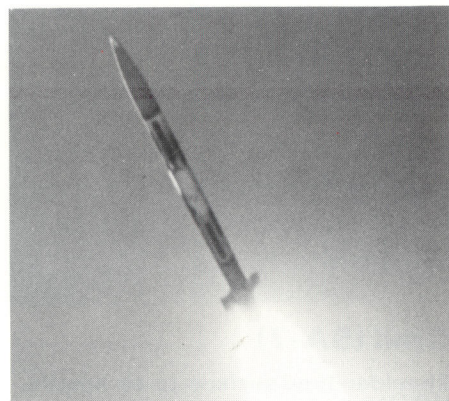
In 1976 the US began a feasibility study of the GSRS. Its main advantages over other systems are its high rate of fire and low unit cost of the rockets. Vought and Boeing were awarded competitive contracts in 1977 to begin development of GSRS systems, following concept definition studies by four US companies, and a declaration of cooperation was signed by the USA, UK and Germany to share in the design and eventual production of the system the

Right: First launch of a GSRS from a tactical container.

Below: GSRS self-propelled launcher/loader undergoing tests.

same year. Vought and Boeing were expected to enter a competitive 'shoot off' to their systems at White Sands Missile Range in late 1979.

Short range firings of the Vought GSRS took place in October 1977, followed in November by warhead ground tests, the first GSRS demonstration rocket firing on 5 December and first multiple launch on 19 December. The first rocket launch from a tactical container was made in April 1978. Following a certain amount of redesign, the first launch of a revised rocket and first three rocket launch from a common launch pod took place on 1 December and 13 December 1978 respectively. When production eventually gets underway, more than 5,000 GSRS rockets will be built every month.



USA

Guideline (V750VK) (SA-2/SA-N-2)

USSR



Surface-to-air missile. In service.

Data: 'Mk 2' version

Powered by: Liquid-propellant sustainer; solid-propellant booster

Airframe: Tandem two-stage missile. Booster is cylindrical with cruciform cropped-delta fins, two of which have trailing-edge control surfaces. Smaller-diameter second stage has cylindrical body with flared skirt, fixed cruciform wings about mid-way between nose and tail, and small cruciform tail control surfaces, all indexed in line with booster fins. Small cruciform vanes on nose

Guidance and Control: Automatic radio command. Control by movable tail surfaces and control surfaces on booster fins

Warhead: High-explosive, weighing 288lb (131kg) with contact or proximity fuse, or detonated by command (see below)

Length: 35ft 1.5in (10.70m)

Body diameter: Booster 2ft 3.5in (0.70m)
Second stage 1ft 8in (0.50m)

Wing span: 5ft 7in (1.70m)

Launch weight: approx 5,070lb (2,300kg)

Max speed: Mach 3.5

Slant range: approx 25-31 miles (40-45km)

Effective ceiling: over 11.2 miles (18km)

Development and Service

Most widely used of all Soviet anti-aircraft missiles, 'Guideline' was first displayed in Moscow in 1957. It serves in the Soviet Union and the Warsaw Pact countries, and has been supplied in vast numbers to Afghanistan, Algeria, China (also locally built), Cuba,

Above: 'Guideline Mk 2s' photographed during the 1977 Moscow parade.

Egypt, India, Iraq, Libya, Mongolia, North Korea, Syria, Vietnam and Yugoslavia. The number deployed in the Soviet Union is gradually declining as greater numbers of 'Goa' and 'Gammon' missiles became operational.

'Guidelines' captured by Israeli forces during the 1967 war were said to bear the Soviet designation V750VK, with the designation V75SM applicable to the entire weapon system. This includes a Zil 157 semi-trailer transporter-erector vehicle or new type transporter, radar van and generators. The US designation is SA-2, or SAM-2; while the version carried on a twin-launcher by the Soviet Navy cruiser *Dzerzhinski* is known as SA-N-2. 'Guideline' has undergone considerable development. The original version, which might be referred to for convenience as the 'Mk1', was similar to the first-generation US Nike Ajax in many design features and probably had a comparable performance. Initially the nose vanes were rectangular, but the 'Mk 2' version captured by the Israelis had cropped-delta vanes. The latest 'Mk 4' version, first displayed in Moscow in 1967, is about 15in (40cm) longer than the 'Mk 2', and lacks the latter's nose vanes and booster control surfaces. It was described by the Soviet commentator as being far more effective than earlier versions, which may imply use of a nuclear warhead in the bulged, white-painted nose-cone.

Guild (SA-1)

Surface-to-air missile. In service.

Powered by: Liquid-propellant rocket motor

Airframe: Cylindrical body, with pointed ogival nose. Cruciform cropped-delta wings, each with trailing-edge control surface. Cruciform foreplane control surfaces indexed in line with wings

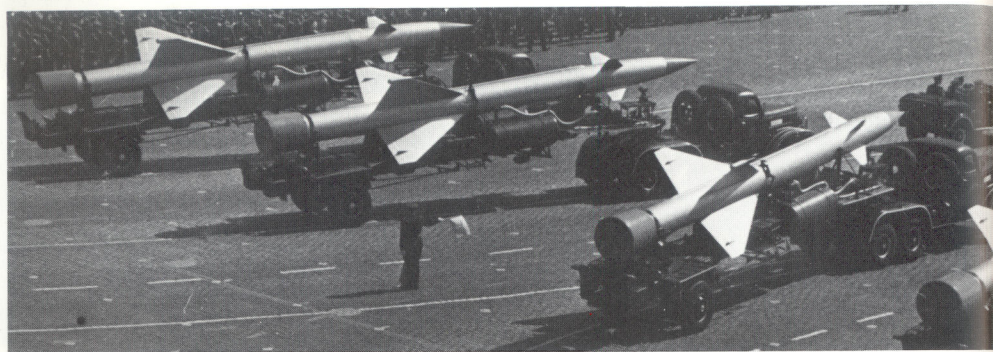
Guidance and Control: Control by foreplanes and wing trailing-edge surfaces

Warhead: High-explosive

Length: 39ft 0in (12.0m)

Body diameter: approx 2ft 3.5in (0.70m)

Range: approx 20 miles (32km)



HARM (AGM-88A)

High-speed air-to-surface anti-radar missile. Under development.

Prime contractor: Texas Instruments Inc

Powered by: Thiokol solid-propellant rocket motor

Airframe: Cylindrical body with ogival nose.

Cruciform double-delta wings indexed in line with cruciform tail fins

Length: 13ft 8in (4.17m)

Body diameter: 10in (0.254m)

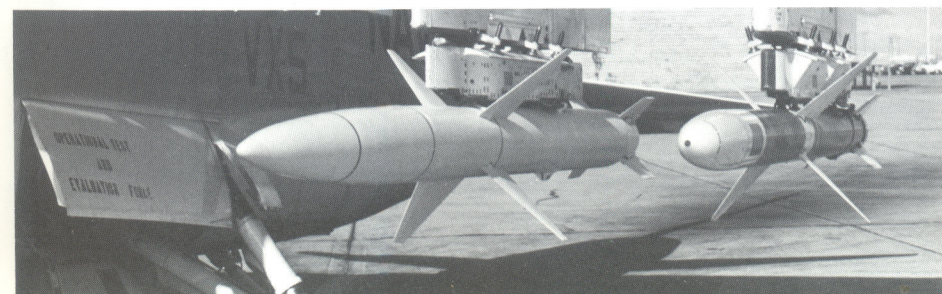
Wing span: 3ft 8.5in (1.13m)

Launch weight: 780lb (354kg)

Range: over 10 miles (16km)

Development and Service

Little information on this new missile is yet available. Its development was prompted by experience in Vietnam, where Soviet-built radars were often able to detect oncoming first-generation anti-radiation weapons such as Shrike and shut down before the



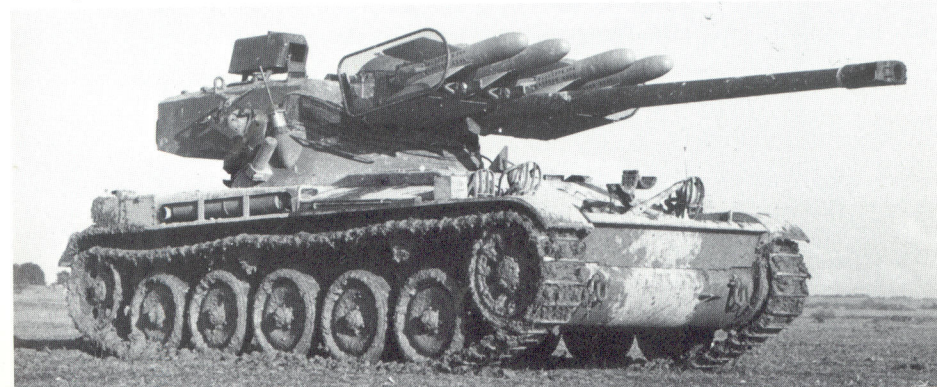
USSR

Development and Service

'Guild' was the second type of Soviet surface-to-air missile displayed in a Moscow parade, on 7 November 1960. Unlike 'Guideline' it has no separate booster. Although 'Guild' has been a standard defensive weapon in the USSR since 1954, there is no evidence to suggest that it has been exported. Continued deployment must be doubtful as the missile is obsolete.

Harpon

France



Anti-tank missile. In service.

Prime contractor: Nord-Aviation/Aérospatiale, Division Engins Tactiques

Powered by: Two stage solid-propellant rocket motor

Guidance and Control: Wire-guidance, using TCA optical aiming/infra-red tracking system. Control by varying sustainer efflux thrust

Length: 3ft 11.75in (1.21m)

Body diameter: 6.5in (0.164m)

Wing span: 1ft 7.5in (0.50m)

Launch weight: 67lb (30.4kg)

Max range: 9,840ft (3,000m)

Development and Service

Harpon is externally similar to the SS.11 B.1 anti-tank missile, with similar performance and

Above: Harpon missile on an AMX-13 tank.

alternative warheads, but utilises the TCA type of automatic guidance described under the AS.30 entry. It was, in fact, the first of a long series of weapons which Nord-Aviation (now Aérospatiale) adapted or designed to use this guidance system. Harpon has proved able to operate effectively over ranges as small as 1,200ft (400m) as no time is lost by the operator having to acquire the missile after launch. It is normally deployed on a launcher turret carried by light armoured vehicles, and is claimed to offer a defence against head-on attack by low-flying fixed-wing aircraft or helicopters in a surface-to-air role. Harpon is operated by France, West Germany and Saudi Arabia, although HOT missiles are generally replacing Harpons.

Harpoon (AGM-84A and RGM-84A-1)

USA

Air-to-surface, surface-to-surface and subsurface-to-surface anti-shiping missile. In production and service

Prime contractor: McDonnell Douglas Astronautics Company-East

Powered by: Teledyne CAE J402-CA-400 turbojet engine, rated at 660lb (299kg)st Aerojet solid-propellant booster for surface-to-surface and subsurface launch only

Airframe: Cylindrical body, with ogival nose. Cruciform wings and cruciform tail surfaces, indexed in line, and foldable for some launch platforms. Flush air intake for turbojet. When tandem booster is fitted, its cruciform fins are indexed in line with missile fins.

Guidance and Control: Terminal guidance by Texas Instruments active radar seeker. Midcourse guidance unit by IBM, consisting of a digital computer and strapdown attitude reference system. Altitude

monitored by a Honeywell radar altimeter. Control by tail surfaces, each powered by electromechanical actuator

Warhead: High-explosive blast type, weighing 500lb (225kg)

Length: AGM-84A 12ft 7in (3.84m)

RGM-84A-1 15ft 0in (4.57m)

Body diameter: 1ft 1.5in (0.34m)

Wing span: 3ft 0in (0.91m)

Launch weight: AGM-84A 1,150lb (521kg)

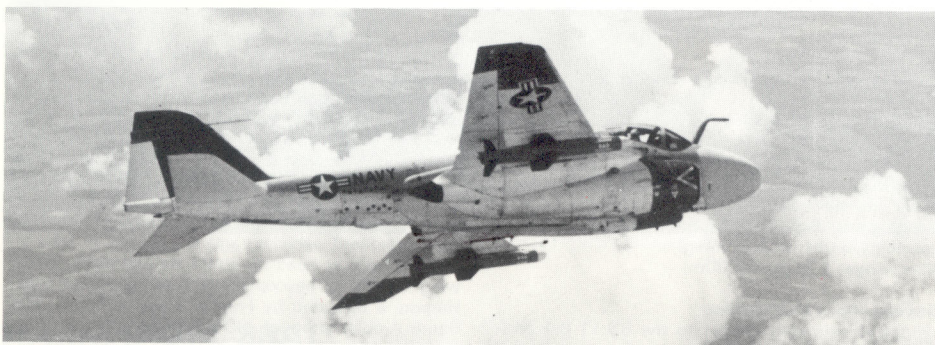
RGM-84A-1 1,470lb (667kg)

Cruising speed: High subsonic

Range: 80 miles (50km)

Development and Service

After three years of research and study, and evaluation of competing tenders from five major US aerospace companies, McDonnell Douglas was named prime contractor for this important all-weather anti-ship weapon in June 1971. Harpoon has since been developed under the direction of the



US Navy's Naval Air Systems Command, and by mid-1974 Harpoons had been launched from ships, P-3 Orion aircraft, hydrofoil patrol boats and submarines. Pilot production go-ahead by the Navy was authorised in July 1974. Operational evaluation and test were completed in July 1977. Harpoon is compatible with Asroc, Tartar and Mark 26 launchers, as well as different types of aircraft. A data processor common to all launcher systems provides all targeting data to the missile, and no inputs from the platform are required after launch. In a typical air launch, the AGM-84A Harpoon descends in a programmed dive until pullout is commanded by the radar altimeter. The missile then levels out and flies to the target at a wave-skimming altitude. In the last few seconds before impact, it pitches up and dives at the target to avoid close-in defences and to enhance warhead effectiveness. For ship launch, the booster-assisted RGM-84A-1 missile is launched from existing launcher platforms at a low elevation angle and follows a ballistic trajectory until booster separation. The sustainer engine is then started and the missile descends to cruise altitude, following the same trajectory as that for air launch. A canister launcher is used to adapt Harpoon to surface ships where standard types of launchers are not available. The canister serves as a shipping container and provides a protective environment in operational use.

Top: Harpoon launch.

Above: Air-launched Harpoons, without first-stage boosters, carried by an Intruder.

The submarine-launched configuration is the same as for the canister launcher, except that the missile is installed in a buoyant capsule. After exiting the torpedo tube, the capsule rises to the surface, using control fins to maintain the required altitude. Upon broach, the capsule ends are jettisoned and the Harpoon booster ignites, propelling the missile out of the capsule and into the same trajectory as that used in surface launches. All versions are fitted with counter-countermeasures devices.

The US Navy currently expects to install Harpoon weapon systems on all its guided missile cruisers and destroyers, Spruance class destroyers, Oliver Hazard Perry class guided missile frigates, missile-armed patrol hydrofoils, nuclear attack submarines, and Orion, Intruder and Viking aircraft, totalling about 1,300 units. Twelve other countries have ordered Harpoon systems, and the capsule and electronics for the submarine-launched configuration for the Royal Navy and others are being manufactured under licence in the UK by Lucas Aerospace. Production of Harpoon will continue until 1986.

Hawk (MIM-23A) and Improved Hawk (MIM-23B) USA

Surface-to-air close-range missile. In production and service.

Data: Improved Hawk

Prime contractor: Raytheon Company

Powered by: Aerojet XM112 dual-thrust solid-propellant motor

Airframe: Cylindrical metal body with pointed ogival nose. Long-chord cruciform wings, each with trailing-edge elevon

Guidance and Control: Continuous-wave semi-active radar homing system by Raytheon. Control via elevons

Warhead: High-explosive

Length: 16ft 8in (5.08m)

Body diameter: 1ft 2.5in (0.37m)

Wing span: 3ft 11.4in (1.20m)

Launch weight: 1,378lb (625kg)

Max speed: Mach 2.5

Max range: 25 miles (40km)

Ceiling: over 59,000ft (18,000m)

Development and Service

Manufactured in thousands, in Europe and Japan as well as by Raytheon in America, Hawk (Homing-All-the-Way Killer) is the low/medium-altitude anti-aircraft weapon which set the pace in this difficult role. As early as January 1960 a Hawk intercepted and destroyed an Honest John supersonic artillery rocket, so becoming the first missile to bring down a ballistic missile. Later, Hawks achieved equal successes against a smaller Littlejohn and Corporal guided ballistic missile. They became operational in August 1960 and were subsequently deployed by the US Army and Marine Corps in Europe, Korea, Okinawa, the Panama Canal Zone and Vietnam. Other nations that received Hawks included Belgium, France, Israel, Italy, Japan, Netherlands, Saudi Arabia, South Korea, Spain, Sweden, Taiwan, Thailand and West Germany.

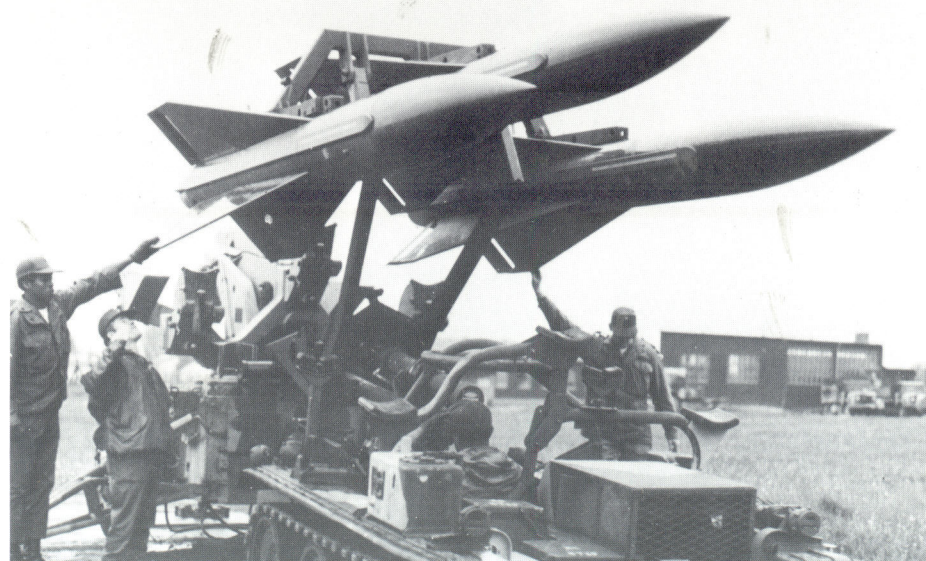
The complete Hawk weapon system is transportable by fixed-wing aircraft and helicopters. A typical battery consists of six three-round

launchers, a tracked loader which collects three missiles at a time for delivery to the launchers, a pulse acquisition radar, a CW acquisition radar, a range-only radar, two target illumination radars and a battery control centre. The original trailer-type launcher was replaced in some US Army units by a self-propelled launcher based on an M727 tracked vehicle able to tow an item of ground support equipment. A platoon has three vehicles. The effectiveness of Hawk, down to treetop level, results from the fact that its radars can pick out reflected signals from a moving target at low altitude from the mass of signals reflected by objects on the ground. When, in certain operations, it is necessary to bring the missiles into action quickly, and with a minimum of equipment, an assault fire command console can be used. This lightweight unit has been developed to permit firing with the addition of only a single launcher, illuminator, generator, loader and pallet, and missiles.

In 1964, Raytheon began development of Improved Hawk, a completely redesigned missile with solid-state guidance package, larger warhead and improved Aerojet propulsion system using an upgraded and higher-impulse polyurethane propellant. Ground support equipment has also been updated in this system which has better ECM protection. Improved Hawk is in full production and is deployed with or has been ordered by the US Army and Marine Corps, Denmark, France, Greece, Iran, Italy, South Korea, Kuwait, Netherlands, Saudi Arabia, Spain, Sweden, Taiwan and West Germany.

A new self-propelled version of Improved Hawk has also been built, based on the Lockheed eight-wheel Dragon-Wagon all terrain vehicle. This system allows greater mobility and so can react rapidly to changing situations, thus increasing its usefulness and survival probability. Interest in the system has been expressed by several countries.

Below: Improved Hawk missiles being loaded on a launcher.



Hellfire

Air-to-surface missile. Under development

Contractor: Missile Systems Division, Rockwell International

Guidance and Control: Semi-active laser homing guidance. Control by wing flaps or movable vanes, depending on missile

Launch weight: Expected to be about 90lb (41kg)

Development and Service

Hellfire is under development as a helicopter-launched modular missile for attacking armoured vehicles and suppression of air defence sites. It will be carried by the AH-64 advanced attack helicopter. The missile will be potentially capable of carrying any one of three seeker heads, but the initial version will use laser homing guidance. Tests have been carried out, using modified Rockwell International Hornet missile airframes and Rockwell laser seekers, at the Army Missile Command, Redstone Arsenal, Alabama.

Hughes Aircraft and Rockwell International were awarded competitive initial contracts, under which each was to build prototype missiles, a launcher, cockpit mockup and other equipment for evaluation. Rockwell International was selected as prime contractor and awarded a follow-on engineering development contract in 1976. Further development plans cover competitive development of additional seekers to provide a true fire-and-forget and air defence suppression capabilities.

Honest John (MGR-1)

USA



Above: Hellfire missiles on a Hughes YAH-64 helicopter.

Surface-to-surface unguided artillery missile. In service.

Data: MGR-1B

Prime contractor: US Army Missile Command (USAMICOM)

Powered by: Hercules M-31A1 single-stage solid-propellant rocket motor

Airframe: Cylindrical metal body, with bulged ogival nose-cone and four clipped-delta tail-fins.

Guidance and Control: Spin stabilisation only; initial spin imparted by Thiokol rockets aft of warhead and maintained throughout flight by canted tail-fins.

Warhead: Alternative nuclear or high-explosive, weighing about 1,500lb (680kg)

Length: 24ft 9.5in (7.55m)

Body diameter: 2ft 6in (0.76m)

Fin span: 4ft 6in (1.37m)

Launch weight: 4,719lb (2,140kg)

Max speed: Mach 1.5

Range limits: 4.6-23 miles (7.4-37km).

Development and Service

Although unguided, this big artillery rocket has provided powerful nuclear support for NATO and Allied armies for well over two decades. Its development was undertaken by Douglas, under the technical supervision of the US Army's Ordnance Missile Laboratories at Redstone Arsenal, Alabama. Firing tests began in 1951, only one year after receipt of the initial contract, and the original MGR-1A version of Honest John was manufactured subsequently in very large numbers by both Douglas and Emerson Electric.

Continued development led to the MGR-1B, reduced in length by about 2ft 5.5in (0.76m) but with improved performance. This version entered first-line service in 1960 and was deployed by US Army units in Europe and Japan, as well as by other countries such as Britain, Belgium, Denmark, France, Greece, the Netherlands, South Korea, Turkey and West Germany. The US Marine Corps formed three Honest John batteries, but disbanded them when the weapon system proved too cumbersome for amphibious operations. Several NATO nations still operate Honest John, although it has been or is being generally replaced by Lance.

HOT

Anti-tank missile. In production and service.

Prime contractor: Euromissile (Aérospatiale, Division Engins Tactiques/Messerschmitt-Bölkow-Blohm GmbH)

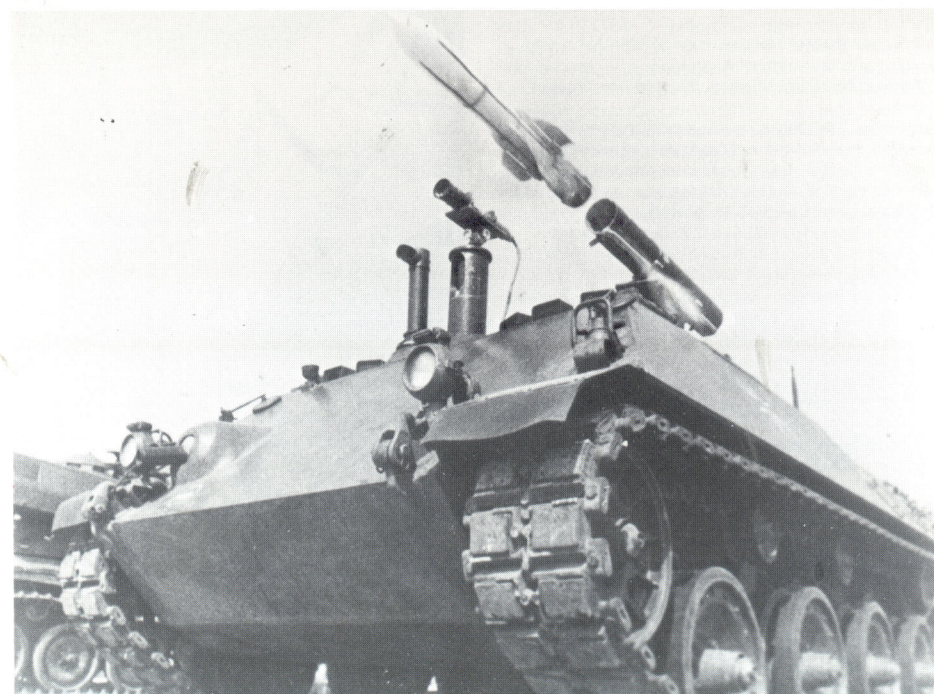
Powered by: Two-stage solid-propellant rocket motor

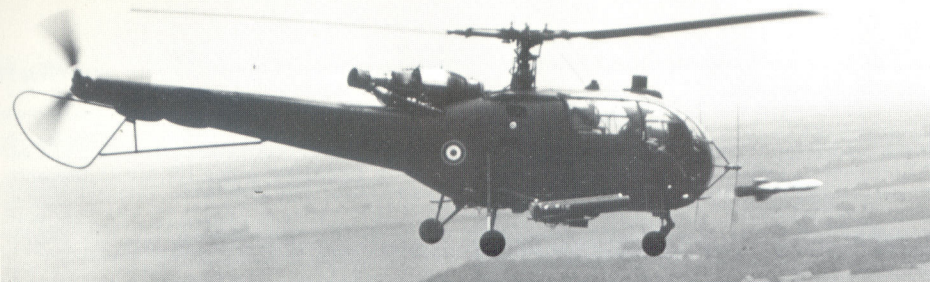
France/Germany

Airframe: Basically cylindrical body, with aft section of increased diameter and bulged ogival nose. Four flip-out fins

Guidance and Control: Wire guidance, using TCA optical aiming/infra-red tracking system. Spin-stabilised by fins. Control by vanes in rocket exhaust

Below: HOT launch from a Casemate vehicle.





Warhead: Hollow charge weighing 13.2lb (6kg)
Length: 4ft 2.5in (1.27m)
Body diameter: 5.75in (14.3cm)
Fin span: 1ft 0.25in (0.31m)
Launch weight: 52lb (23.5kg)
Max speed: 560mph (900km/h)
Range limits: 250-13,100ft (75-4,000m)

Development and Service

HOT (High-subsonic Optically-guided Tube-launched) is similar in configuration to MILAN and uses the same kind of guidance system, but is larger and has a higher performance. It is intended to be mounted on light armoured vehicles and helicopters, or to be installed for fortification defence. During demonstration firings in 1970, two HOTs from a French AMX-13 tank impacted within 12in (30cm) of the centre of a target over a range of 11,480ft (3,500m). Others were fired over a similar range, during 1971-72, from an Alouette III helicopter; in

Above: HOT launch from an Alouette III helicopter.

1973-74 from an SA 341 Gazelle helicopter, in conjunction with a stabilised sight; and in 1974 from an MBB BO105 helicopter. Series production was initiated in 1976, including an air-to-surface installation for Gazelles of the French Army, and another for BO105s of the German Army, which were first delivered in 1977. Trials on Lynx and Dauphin helicopters took place in 1978. Several other countries have ordered HOT missiles. HOT, like MILAN is claimed to have potential in a surface-to-air role, against head-on attack by helicopters and low-flying fixed-wing aircraft. Its flight time to target is 17 seconds over 4,000m, compared with 21 seconds of propelled flight over 3,000m of the AS.11 which it supersedes. It is also claimed to have a 90% hit probability.

Ikara

Long-range anti-submarine missile. In service.

Prime contractor: Department of Manufacturing Industry, Government of Australia

Powered by: Dual-thrust solid-propellant rocket motor

Airframe: Basically square-section body, with detachable mid-mounted cropped-delta wings, elevon control surfaces and upper and lower tail-fins. Torpedo cradled in underbody recess

Guidance and Control: Radio/radar guidance/tracking system, receiving signals from automatic target-prediction equipment on board launch-ship. Control via elevons

Warhead: American Type 44 lightweight acoustical homing torpedo, or other types of torpedo

Length: 11ft 0in (3.43m)

Wing span: 5ft 0in (1.53m)

Max speed: Subsonic

Range: up to 11 miles (18km)

Development and Service

This long-range anti-submarine missile was designed originally to provide navies with a rapid-reaction

Right: Ikara inside its launch bin on a ship.



Australia

weapon which would guarantee a high degree of accuracy under all weather conditions. The Australian Navy has three destroyers of the Perth class each fitted with two single-round launchers, and six River class destroyers each with one launcher. A version known as RN Ikara has been developed jointly by the Australian Department of Manufacturing Industry and Hawker Siddeley Dynamics of the UK for the Royal Navy. This system has been installed in HMS *Bristol* and in eight Leander class frigates. It uses a Vickers-designed missile handling and launch system with Australian-supplied tracking and guidance systems.

Another variant of the system, known as Branik, was manufactured in Australia to arm four Niteroi class destroyers of the Brazilian Navy.

Ikara missiles are stowed in the shipboard magazine as torpedo-fitted bodies, less the detached wings and tail fins. The missile launcher loading process involves automatic selection and conveyance of the body unit to a safety assembly

Indigo-MEI

Surface-to-air short-range missile. In production and service.

Prime contractor: Sistel-Sistemi Elettronici SpA
Powered by: Solid-propellant rocket motor of 8,267lb (3,750kg) st

Airframe: Cylindrical light alloy body with pointed ogival nose. Movable cruciform wings mid-way along body, indexed in line with fixed cruciform tail-fins

Guidance and Control: Beam-riding/radar command guidance. Control by movable cruciform wings

Warhead: High-explosive warhead of fragmentation type, with Hawker Siddeley Dynamics impact/infrared proximity fuse. Weight 46lb (21kg)

Length: 10ft 10in (3.30m)

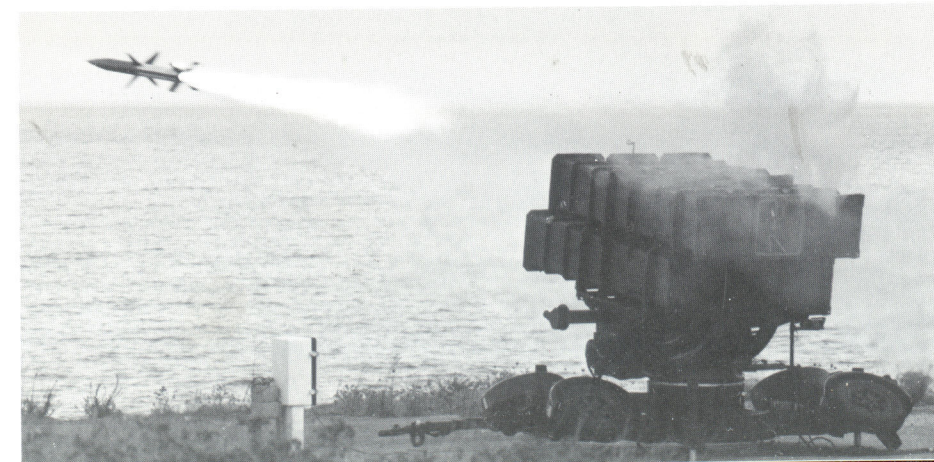
Body diameter: 7.7in (0.195m)

Wing span: 2ft 8in (0.813m)

Launch weight: 265lb (120kg)

Max speed: Mach 2.5

Below: Indigo-MEI launch from a trailer.



area. Naval ratings quickly fit the wings and fins. Following movement of the loading staff to a safety area, the complete missile is automatically transferred into the rotatable tilting launcher in the firing area. When a potential target is detected by the launch ship's sonar, or through helicopter or other ships' sonars, the launcher is swivelled to an optimum aiming direction. The launching ship's computer and guidance control system establish an optimum missile flight path profile and the missile is automatically pre-flight checked. Immediately after firing, the in-flight missile is acquired by a broad-beam stabilised tracking radar, which is automatically switched to narrow beam as the missile stabilises on to its computed flight path. At the optimum position for attack, the torpedo is released and lowered into the water by parachute. On water impact, the parachute connections to the torpedo are disengaged and the torpedo proceeds on a target homing run. Meanwhile, the flight vehicle continues on a flight path to take it out of the target zone.

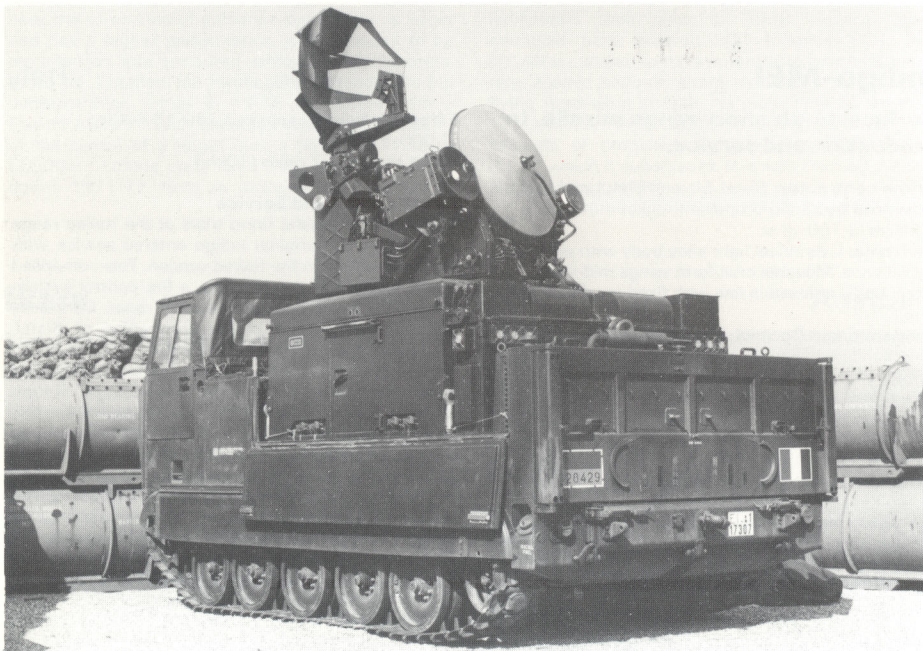
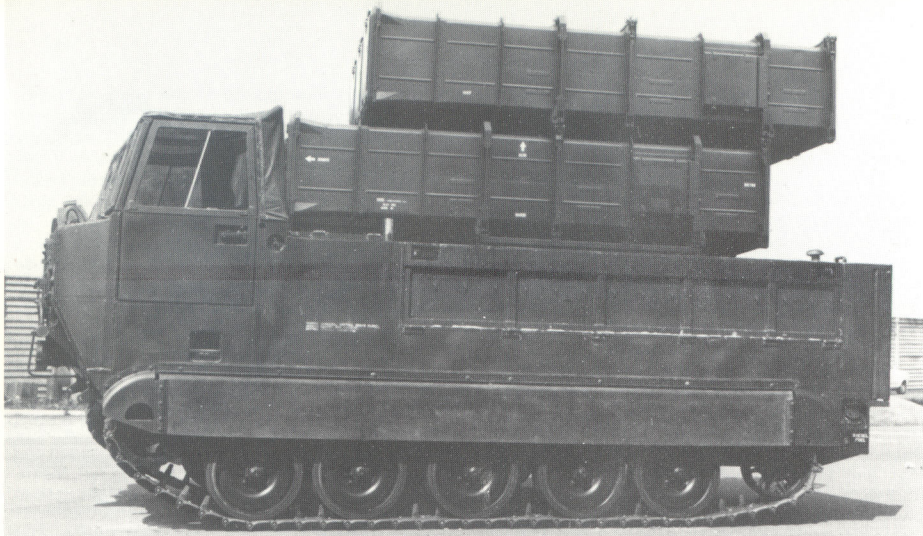
Italy

Effective height: approx 3,280-16,400ft (1,000-5,000m)

Slant range: 6.2 miles (10km)

Development and Service

Following successful firing trials at the Italian range in Sardinia, the original Indigo entered service with the Italian Army in the towed version. This comprised trailer launchers, power units, a fire control system and LPD/20 pulse Doppler search radar. Contraves Italiana, one of the parent companies of Sistel, developed an integration kit enabling the missile to be operated by anti-aircraft gun batteries equipped with the Super Fledermaus fire control system designed by Contraves AG of Switzerland. The original Indigo is no longer in production or service. It has been superseded by the all-weather Indigo-MEI. Although the latter can be trailer or ground launched, it is normally a self-propelled missile system, based on M548 tracked vehicles. A battery comprises a carrier vehicle with search and tracking radars (Selenia radars replacing the original Thomson-CSF Eldorado/Mirador radars), the fire control system and



Top: Indigo-MEI tracked launch vehicle.

Above: Indigo-MEI fire control unit.

power supply; two launch vehicles with six missiles in containers each on trainable mounts; and a logistic support vehicle with six or twelve replacement missiles.

Indigo-MEI uses beam-riding guidance or can be controlled by a radar command guidance link using optical or infra-red tracking. The target is threat evaluated automatically by a Pulse Doppler MTI (Moving Target Indicator) search radar with track-

while-scan technique. The target can be attacked in radar and optical modes (the latter best for fair weather, low target and critical angle interceptions), with one or more missiles. Infra-red flares housed in the tail fins allow IR tracking. One fin also carries a telemetry transmitter antenna for use with a telemetry and training head.

Development started in 1971 and Indigo-MEI was tested by the Italian Army in 1977. It has now been selected by the Italian Army to provide protection for tanks and troops on the move and for defending fixed installations against helicopter and fixed-wing aircraft attack.

KAM-3D (Type 64 ATM-1)

Anti-tank missile. In service.

Prime contractor: Kawasaki Heavy Industries Ltd

Powered by: Two-stage solid-propellant rocket motor, first stage rated at 286lb (130kg) st and second stage at 33lb (15kg) st

Airframe: Cylindrical body, with a blunt-tip conical centre-body on the rounded nose. Large rear-mounted cruciform wings, of all-metal construction, each with full-span trailing-edge spoiler

Guidance and Control: Wire guidance, with gyro-stabilisation. Control by spoilers on wings

Warhead: High-explosive

Length: 3ft 4in (1.02m)

Body diameter: 4.7in (0.12m)

Wing span: 1ft 11.5in (0.60m)

Launch weight: 34.6lb (15.7kg)

Cruising speed: 190mph (306km/h)

Range limits: 1,150-5,900ft (350-1,800m)

Development and Service

Kawasaki started development of this missile in 1957, under contract to the Technical Research and Development Institute of the Japan Defence Agency. Seven years later, after several hundred rounds had

Right: KAM-3D on a helicopter.

Below: Jeep equipped with two KAM-3Ds in box launchers.

been test fired, production was authorised for the Japan Ground Self-Defence Force, under the official designation Type 64 ATM. Experience has shown that the KAM-3D's velocity control system is so effective that three out of four unskilled operators can hit the target with their first round after simulator training. Skilled operators can achieve a 95% success rate. A two-man firing team is standard, using a push-button control box. The KAM-3D can be fired by infantry as single rounds or from multiple-round emplacements. It is also carried on jeeps and helicopters. Optical tracking is aided by a flare in daytime; at night the rocket exhaust provides adequate visual reference.

